

M&S PROCESS MODULE

INTRODUCTION

In this module, you will learn about the challenges of developing effective models and simulations, and examine a process model depicting the systemic and iterative steps required to ensure the successful development of modeling and simulation applications. As you learned earlier, while models and simulations can serve many purposes, the full potential for a model or simulation can only be achieved if it is designed for a specific purpose and if it is used appropriately. This module discusses the process of developing models and simulations to ensure that they meet their intended purpose. If this process is followed, it is much more likely that the model or simulation will achieve its potential to meet the needs of the end-user, whatever those needs may be.

PROCESS OVERVIEW

In this topic, you will examine the M&S process model, and explore several development guidelines to utilize while following the iterative steps within this model. The potential benefits of modeling and simulation as previously discussed in this course can only be achieved if development of the final product is designed to meet the needs of the end-user.

Unfortunately, mistakes are often made that result in falling short of that goal. For example, the end-users are not always kept involved throughout the development process, so their needs may be lost amid the many tradeoffs made during the project; or there is a rush to get into production before fully understanding which tradeoff options will most likely result in an optimal design. These mistakes have been made throughout

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the history of M&S and are still being made today. Why? Because many times, modeling and simulation is not recognized as the *system* that it is. As a system, any input or tradeoff at any point along the way has the potential to affect the validity and the quality of the final product.

Activity: Insert activity that explores several examples of projects that went awry...users were not involved and there was a rush into production. Let user explore what the final product was like—seeing the gap between need and final product.

Spotlight: End-users must be involved throughout the M&S development process.

Spotlight: Production should not begin until the design effects of tradeoff options are fully understood.

Effective models and simulations can only be developed through a systemic and iterative process, like the one shown here (Amico, Bruzzone, & Guha, 2001). It consists of discernable phases, each necessary to meet the needs of the user. If any phase is skipped or given insufficient attention, the quality of the model or simulation will suffer.

DRILL DOWN: *Critical Issues*

Amico, V., Bruzzone, A. G., & Guha, R. (2001; July) *Critical issues in simulation*. SCS Proceedings, Orlando, FL.

The two arrows shown between each phase in this process model indicate the iterative nature of the process. The green arrows show the “ideal” progression of the process. The orange arrows indicate that it is often necessary to revise the work accomplished in a phase during its evaluation or because of new insights gained during subsequent phases. At the center of the diagram is the validation procedure for monitoring how well the process is resulting in a product that meets user needs. This

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indicates that validation should be a continuous effort that occurs throughout the entire process (Amico, Bruzzone, & Guha, 2001, p.9).

Another way to describe this continuous assessment process is depicted in the validation gap model or “V” diagram (Amico & Clymer, 1992, p. 2.15). This diagram depicts the gap between the end-user needs and the model or simulation that is being developed to meet those needs. As the development process proceeds, the end-user works as a member of the team to reduce this gap (Amico, Bruzzone, & Guha, 2001, p. 9).

DRILL DOWN, Need Vs. Product Gap

Amico, V., & Clymer, B. (April, 1992). *Professional development seminar: Procuring and developing simulators*. Unpublished Manuscript, Orlando, FL, p. 2.5.1.

An essential component of continuous validation is evaluation of the progress of the M&S development effort. During most of the phases of development, evaluations are “formative” (Hays & Singer, 1989, pp. 113-114).

This means that the evaluations of the M&S product are conducted as it is being developed or formed. The results of “formative” evaluations help revise plans so that the project team can constantly move toward “closing the gap” between the current state and the end-user’s needs.

During the implementation phase, the evaluation is said to be “summative” (Hays & Singer, 1989, pp. 113-114). This means it is the summary evaluation of the final M&S product to determine if it meets the needs of the end-user. No M&S product can ever fully meet all needs. Challenges change, technologies evolve, and knowledge of the problem improves. The “summative” evaluation helps identify the gap between a project team’s final M&S application and the end-user’s evolving needs. If the gap is too large,

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then the summative evaluation may call for a return to the need identification phase and the development cycle begins again.

Verification, Validation, and Accreditation, or VV&A, is a “formal” requirement of M&S development in the Department of Defense (Defense Modeling and Simulation Office, n.d., M101, M&S Staff Officer Course; Department of Defense Directive 5000.59. 1994; Naval Studies Board & National Resource Council, 1997, Chapter 4c). This “formal” VV&A is conducted at the end of the process.

Spotlight: VV&A is a formal DOD requirement for end-process review.

Spotlight: However, *validation*, should occur *continuously* throughout the development process to ensure the end-user’s needs are met.

Another important realization is that the development of M&S is a multidisciplinary team effort (Ivanetich, 1997; SMART, 2001). The development team includes individuals with different roles and expertise, which are determined by the purpose and requirements of the model or simulation. For example, computer engineers are needed to write the simulation programs, psychologists are needed to understand human capabilities and limitations when interacting with the simulation, instructional systems designers help construct the learning experiences and performance evaluations, the end-user helps maintain focus on the purpose of the simulation, and program managers orchestrate the entire process and keep the team together. Selection of roles for the team is dependent on the desired outcome of the project. Each team member’s understanding and appreciation of the many roles that are required to properly support a specific M&S project helps to ensure that the project will be successful.

Spotlight: Each M&S team member is important and should understand the value that other team members bring to the effort.

Topic Summary:

In order to create models and simulations that realize their potential by meeting end-user's needs, the development team must faithfully follow the established systemic and iterative process, as depicted in the Process Model. Here are several strategies to employ while following this process:

- Build a multidisciplinary team in which roles are based upon the project's purpose and requirements.
- Ensure that all team members are valued.
- Keep end-users involved.
- Begin production only when you fully understand the end-user's needs.
- Routinely conduct formative evaluation to validate data and progress toward the needs.
- Return to earlier development phases when needed, such as exploring the user's needs in more depth, or revising a design.
- Comply with VV&A requirements.
- Conduct summative evaluation during implementation.

IDENTIFICATION OF THE NEED

In this topic, you will learn about what types of activities typically occur during the earliest phase of development, the "Identification of the Need"; and you will discover what practices should be initiated in order to ensure the creation of an M&S tool that meets the end-user's need. Identification of the Need is the point in the process where it

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is determined whether or not a model or simulation can assist in meeting a real-world challenge or problem. Models and simulations can be developed for many different purposes, but each *specific* model or simulation must be developed for a correspondingly *specific* purpose.

To demonstrate, let's again look at the cube diagram. During the Identification of the Need phase, the M&S development team is formed and begins the process to identify the end-user's need. The end-user should understand that he or she is an important member of the development team and will be involved throughout the entire process. The team must work with the end-user to understand the specific need which the model or simulation will address. For example, one might start by determining in which functional domain the need resides. Development of a simulation to meet an Acquisition need will require different strategies from those to meet a Training or an Analysis need.

When *acquiring* a new aircraft, an existing flight simulator might be used to help design the form and function of the new cockpit. This would be based on pilots using the simulated cockpit data to make determinations on its design, such as visibility of critical displays. That same flight simulator, when used for *training*, would require incorporation of training scenarios and performance assessment, not required in the *acquisition* example. Likewise, the simulator could be used to analyze air combat tactics, requiring a different set of criteria. The specific application area, such as whether there is a need to simulate a human or a piece of equipment and the level of aggregation, such as a single person or a crew of people, must also be identified.

Activity: Insert activity using the cube where learner can investigate another example seeing how the changing need affects the criteria.

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The “formative” evaluation activities during the Identification of the Need phase are primarily analytical. They involve in-depth discussions with the end-user and development of a shared vision of the purpose of the final product. At this stage, the gap between the vision and the final product is wide. If the development team is doing a good job, they should share with the end-user a clear vision of the final product. Nevertheless, much work remains to achieve the team’s vision. Continued interaction with the end-user over the next phases will gradually narrow this gap to ensure that the final product meets end-user requirements.

Once the end-user has articulated the purpose of the model or simulation, the potential tradeoffs involved in the development of this specific product can be identified and plans created to address possible issues or consequences of those tradeoffs (Ivanetich, 1997; Wolff, 1999, p. 8). For instance, some of the initial tradeoffs might be determined by the available resources, critical deadlines, and access to experts. Other tradeoffs will be identified and addressed later during each subsequent phase.

Another important activity during this phase is to begin managing the user’s expectations. As previously discussed, some end-users are influenced by marketing hype and movie-created fantasies (Smith, 1999). If the end-users are involved in the development process, they have a better chance of developing realistic expectations about the capabilities of the end product.

Topic Summary:

During the Identification of the Need phase, the development team is formed, the end-user’s needs are clearly articulated, and a common vision of a projected M&S solution is created. Once the purpose of the final M&S project has been determined,

potential development tradeoffs can be identified and plans for addressing any associated problems can be drafted. At this time, it is critical that the team begins cultivating several best practices to continue throughout the development process. These include:

- End-user involvement
- Continuous formative evaluation
- Management of end-user expectations.

REQUIREMENTS ANALYSIS

In this topic, you will learn what activities typically occur in the Requirements Analysis phase, and you will also examine some of the challenges that are typically encountered during M&S development. During the Requirements Analysis phase, the team shifts its focus from the more general to the more specific by analyzing the end-user's needs in depth, and by defining the project's requirements in sufficient detail to include a description of the target audience, environment and objectives.

Why is this important? A major reason is that if the requirement is too broad, then the resulting simulation can become too complicated, difficult to use—and ultimately less effective. Therefore, it is *critical* that the team work closely with the end-user to fully analyze the project's requirements. Realizing this goal, however, is not as easy as it sounds. Let's listen to Jim Lunsford share his perceptions of how *challenging—and critical*--it is to define the end-user's needs and the requirements of how and where the simulation will be used ...

“One of the biggest challenges in essentially designing a feasible, suitable simulation is getting the customer to articulate their actual requirements. ...One of the challenges that the customer has is accurately defining the specific target audience, the environment that the simulation will be used in, and the actual learning or training objectives...Often times when people desire to create a broader requirement, often times this fails because number one, it causes the

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simulation and design to become overly complicated and this then makes it less effective because it takes longer to use. It's not as effective in every category as far as each requirement. Whereas if you design five sets of simulations, each fairly easy to use, but each focused specific learning or training objectives then you'll be more effective. (Jim Lunsford, videotaped interview, ITSEC, November 2002, Orlando, FL: Integrity Arts & Technology, Inc.)

This obviously refers to the learning objectives that must be articulated for an M&S application that is within the *Training* Domain. But the Requirements must be analyzed and articulated regardless of the domain in which the M&S application will be used.

During this phase, the team is also analyzing its own needs and requirements, judging the skills and talents of each team member against the projected development tasks. Often, the team may recruit additional experts with specific skill-sets. For example, if the analysis has identified the need for a training simulation, the team may need to add experts in learning strategies, instructional development, and human performance psychology. Or, if the requirements indicate that the simulation will be used for logistical analysis, then the team will need to recruit experts in logistics.

These experts then begin to work with the user to develop an in-depth understanding of the need and to identify alternative solutions. This may involve conducting an analysis of alternatives (or AOA) to identify the most feasible approach or approaches. Often times, a simulation can be used to help the team analyze various options by enabling team-members to examine the risks, costs and benefits that are associated with each of the alternative approaches. Sound familiar? This technique of using simulations to support AOA was presented in the Simulations module in reference to a threat analysis involving firearms.

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Validation during the Requirements phase can involve a variety of “formative” evaluations. As demonstrated in the “V” diagram, the purpose of this validation is to gradually reduce the gap between the identified need and the final product.

Typical formative evaluation activities include:

- Asking for continuous feedback from the end-users--which not only helps narrow the gap, but also ensures that their expectations about the final product are realistic.
- Analyzing the required parameters of the supporting model or models,
- Determining the speed of the computational system required to process the data from the model,
- Defining the required characteristics of the user interface for the final simulation (Amico, Bruzzone, & Guha, 2001).

While it is clearly important to conduct continuous evaluation, such an approach is costly and time consuming. Often times, teams are tempted to delay or omit validation in order to meet tight budgets and timelines. While tempting, such an approach can result in many errors, which can reduce the relevance and effectiveness of the final product. According to Dr. Vince Amico (personal communication, June 3, 2002), a founding member of the M&S community, “experience indicates that a project usually continues despite the lack of a validity test at the completion of each phase. This propagation of errors, which continues through each of the phases of development, may result in a final product, which differs from the requirement.” This is a critical point to remember when there is a push to save money and time by limiting validation. While

this approach may hasten production in the short run—it may actually threaten the success of the entire project.

Spotlight: Saving time and money by cutting validation can actually threaten the success of the entire project.

By the end of the requirements phase, the Analysis of Alternatives indicates the most promising concepts and solutions that are selected for *further* study in the Research and Development phase.

However, because this is a *systemic* process, the validity of M&S products can be affected by various inputs that might occur later in the project. For example, an unexpected budget cut, may limit the range of choices such that the team might not be able to pick the most optimal solution to meet the end-user's need. This is another reason why the development team must routinely validate its work and be willing to re-visit earlier design phases when necessary.

Topic Summary:

In summary, during the Requirements Analysis phase, the development team works closely with the end-user to analyze the need in depth and to identify the project's requirements. An analysis of alternatives may be conducted –with or without the assistance of a simulation--to help the team compare the risks, costs and benefits of each option and thereby identify which ones will be most feasible.

To further reduce the gap between the identified need and the final product, the following formative evaluation activities should be conducted:

- solicitation of end-user feedback,
- analysis of the requirements for the supporting model,

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- validation of the computational system speed,
- analysis of the user-interface characteristics.

By the end of the requirements phase, the team should emerge with the most promising concepts and solutions to be studied further in the next phase.

RESEARCH & DEVELOPMENT

In this topic, you will learn about some of the activities conducted while researching and testing the alternative approaches that were identified in the previous phase. And you will discover some important guidelines to follow during the Research and Development phase of M&S development.

In the Research and Development phase, work focuses on determining the best way to produce the simulation. The limited number of alternative approaches that were identified during the requirements analysis phase are tested during R&D to determine the strengths and weaknesses of each approach. This is sometimes referred to as “test and evaluation.” Watch out! This is a narrow use of the phrase which can also be expanded to include testing actual equipment as well as simulations.

It is essential that the end-user continue to be involved in validation of approaches being tested during this phase. This involvement by the end-user becomes even more critical as the project team narrows focus on the most promising alternate approaches. Notice how in the “V” diagram, the gap between development and end-user needs, is gradually narrowing during this phase. This can only occur if the end-user remains routinely involved with the development team.

The “formative” evaluations during R&D usually focus on whether the physical and functional characteristics of the simulation remain supportive of the end-user needs.

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Additions of components or functions, beyond those determined during the needs analysis or those that are only marginally useful from the end-user's perspective, should be minimized or eliminated (Smith, 1999).

While that seems like a simple task it can become difficult to manage because people can often get caught up in the glamour of the technology and often want every possible function, even if those functions don't add value to the end product as defined during the Needs and Requirements Analysis phases. This can happen not only to the end-user but also to team members who are producing the M&S application.

Let's hear what Herb Grover has to say about this challenge...

Keep in mind as you approach the development of this model of simulation ... who the end-user is going to be, who the simulation is being developed for and what the purpose of that simulation is. That will help them keep the whole project in perspective, and when the contractor wants to go off perhaps in areas that aren't going to affect the utility of that simulation, program management can help focus them back to the most fundamental aspect of it, and that is, when this is all built and marketed, will the user be able to execute war plans in it?" (Herb Grover, videotaped interview, ITSEC, November 2002, Orlando, FL: Integrity Arts & Technology, Inc.)

It can take considerable effort to re-direct the project's focus and determine which functions are truly needed. For example, as discussed in the Fidelity Module, while developing VESUB some users wanted to feel motion as well as wind and sea spray. Since this was something the end-users wanted, there was some pressure to include this capability. The team's response was to step back and re-examine the need. From this analysis, it was determined that VESUB didn't require a motion base because the task was so visually dependent. So, even though it was an end-user expectation, it was not an actual need—and therefore was not included.

Activity: Insert activity here.

Spotlight: Only those functions or capabilities that fill the end-need should be added to the M&S application.

A critical issue that emerges during the R&D phase is how to *obtain* complete and accurate data to incorporate into the model (Amico, Bruzzone, & Guha, 2001; Smith, 1999). Data, in its broadest interpretation, must include the characteristics of the physical systems, the environment, and the human element, such as their knowledge and the characteristics of their behaviors. There are some common problems that may be encountered when obtaining data. For instance, incomplete, imprecise and/or unavailable data sometimes make it necessary to make data assumptions.

DRILL DOWN: *Laws of Data*

Smith, R. (1999, March). *Fundamental Principles of Modeling and Simulation*. Computer Game Developer's Conference. San Jose, California, pp 8-10.

DRILL DOWN: *Critical Data Issues*

Amico, V., Bruzzone, A. G., & Guha, R. (2001; July) *Critical issues in simulation*. SCS Proceedings, Orlando, FL, pp.5-7.

This may compromise a simulation if the data are not tagged as being assumed, because it may cause people who are new to the team to overlook the necessary step of replacing assumed data with actual data once it becomes available. Likewise, the conversion of imprecise data to mathematical representation when a computer-based simulation is required can cause major problems in the final product's validity.

Additional issues that are addressed during the R&D phase include usability analyses and refinements of the user interface as well as the development of training materials to help end-users implement the simulation. Also addressed is the fact that a computer-based simulation must have sufficient speed and memory capacity to solve the

simulation models for either real-time or non-real time simulations. Taking all of these issues into account will help guide the project team toward the most viable solution to meet the need.

During all development phases, but especially during R&D, the end-user community may exert pressure to accelerate the process. It is critical to counteract this pressure and balance the need to deliver the final product with the need to make informed decisions about the simulation.

Spotlight: Moving into production before the design is validated will likely result in an ineffective M&S application.

Activity: Insert activity here.

At the end of the R&D phase, the most promising approach is selected and project development can proceed to the production phase.

Topic Summary: In summary, during the Research and Development phase, the team works to identify the best way to produce the simulation. This is done by testing the most promising alternative approaches selected in the previous phase, and ultimately determining which option will be the most successful. If the team is working effectively, the gap between the end-user's need and the project development should be narrowing. However, there are several pitfalls that may prevent this from happening.

This topic reviewed the following guidelines that should be followed to keep the project on track:

- Continue to involve the end-user. This is more critical now that the focus is narrowing even further.
- Only include functions or characteristics that support the end-users' needs.

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- Continue validation and formative evaluation activities such as analyzing and refining the interface and training materials and ensuring that there will be sufficient technological capabilities to support the simulation.
- When possible, obtain complete and accurate data. Flag all data assumptions.
- Balance the need to deliver the final product with the need to make informed development decisions.

PRODUCTION

In this topic, you will examine some of the activities and challenges involved in transforming the design of a model or simulation into an actual product. The Production phase is when the design of the simulation is refined and finalized. If the end-user requires a computer-based simulation, it is during this phase that the computational system, hardware, and software are produced. The requirements of the computational system were determined during R&D, but additional refinements may be needed to match changing end-user requirements or technological advances.

In previous phases of the M&S process cycle, both of the terms “models” and “simulations” have been used. During the R&D phase, efforts continue to refine and modify the model, and it is important that the model be designed to be accessible for these purposes. However, beginning with the production phase, the focus now shifts to the dynamic implementation of that model within the simulation.

Spotlight: During the production phase, the focus shifts from *developing* the model to dynamically *implementing* that model into the simulation.

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The end-user must continue to assist in validating the product against his or her needs during this phase. If the end-user has been a fully involved team member throughout previous phases, the validation gap should be continually decreasing.

The “formative” evaluations during production often focus on the user interface of the simulation. This is also when training of the simulation end-user should be conducted (SMART, 2001). This training is essential so that the simulation can be properly used as soon as implementation begins. This is not only true for simulations in the Training domain. To be able to use simulations most effectively, users almost always require training.

Some of the tradeoff issues that may have to be addressed during the Production phase include: budget planning limitations (if the production time and cost of the simulation system exceeds preliminary estimates, the requirements may need to be scaled back); and the length of the development cycle (if the simulation is complex, it may take a long time to develop). If constrained by time, the complexity of the simulation may need to be reduced.

Topic Summary: To summarize, during the Production phase designs are transformed into products. Activities that teams typically engage in during this phase include refining and finalizing the simulation design, implementing the model into the simulation, producing the computational system, hardware and software--as well as continuing user involvement through interface evaluation and training.

Some of the tradeoffs that the team may encounter during the Production phase are related to budget limitations and the length of the development cycle. For example, if there are unexpected constraints on time and money, some of the original requirements

may have to be scaled back. Or if the project is taking too long to complete, some of its complexity may need to be minimized.

To properly respond to such constraints, the team and the end-user should re-visit earlier phases in the Process Model—such as re-analyzing the need and re-defining the project’s requirements. This is just another example of how recursive and systemic the development process is. While it is the ideal to proceed directly through the different stages, in most cases the team finds itself returning to previous stages. In this way, and by involving the end-user in this recursive process, the gap between the identified need and the final product will continue to narrow—so that by the Implementation phase the M&S application should be relatively close to meeting the end-user’s need.

IMPLEMENTATION

In this topic, you will explore why it is important for development teams to be involved in the implementation of their final products. During the Implementation phase, the simulation is delivered to the end-user community and is applied to the original challenge or need. Hopefully, the continuous validation and user-involvement that occurred throughout the development process narrowed the gap between the need and the product so much so that it makes implementation efficient, simple, and *exciting!* However, new issues are likely to arise as attempts are made to use the simulation in its real-world context. This is especially true when the design process extends over several years--as it often does.

Evaluations done during implementation are called “summative.” The intent is to determine if the final product actually meets the needs of the end-user. For example, if it is a training simulation, a training effectiveness evaluation should be conducted with a

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representative sample of the trainees who will use the simulation. If possible, the training effectiveness evaluation should assess the trainees' performance on the job. However, implementation should not be considered the "final" phase of M&S development. New challenges, new technologies, and new insights emerge throughout the development cycle. These lead to the identification of new and additional needs, which begin the cycle again.

Topic Summary: During the implementation phase, the simulation is delivered to the end-user and is applied to the original need. If the development process utilized sufficient validation and user-involvement--and the team incorporated lessons learned from these activities into its design--then the implementation process should be efficient and rewarding.

A summative evaluation should be conducted to measure how well the final M&S application meets the end-user's needs. The results of this evaluation can inform the development team on any areas that need revision. This of course would send the team back to the beginning of the Process Model to the Identification of Needs phase—and the development process would begin once again!

Activity: Insert activity here.

CHALLENGES

In this topic, you will revisit the importance of following the systemic and iterative development process, as depicted in our Process Model while creating models and simulations and hear some experts discuss the mistakes that can occur when this process is not implemented appropriately. One of the biggest challenges that the M&S community faces regarding the development of models and simulations is that even

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though there is a defined process, *time and time again* the steps are not followed. This causes the same mistakes to happen repeatedly, resulting in the loss of time, resources, and end-user trust.

Common mistakes include: not validating during every phase, failing to involve the end-user throughout the process, not keeping the model separable from the simulation so it can be separately validated and/or changed, going into production too quickly, failing to manage end-user expectations, and adding components or functionalities that do not support the end-use. Let's hear from some of our experts as they reflect on these challenges. First, James Coombs has some words of wisdom about conducting validation...

“I think one of the most important things to know in developing a model or simulation is how to attain the validation data that you need for that simulation. That's very difficult, but a strong validation program yields a lot of confidence in your Model and Simulation. It's costly. It's time consuming, but it's absolutely essential. (James Coombs videotaped interview, ITSEC, November 2002, Orlando, FL: Integrity Arts & Technology, Inc.)

Next, Herb Grover talks about the importance of user involvement....

.... there needs to be periodic review from the end-user on the probable utility of that simulation when it ultimately gets to them. ... often this happens at the very end it's turned over to the folks who are actually going to operate this at the simulation centers across the DoD. That is their opportunity for real feedback and sometimes that feedback comes too late. The modification that they are going to suggest may be of such detail, and of such a nature that it's cost prohibitive to go back and change the software to accommodate their requests. So, the user community needs to be represented...Herb Grover videotaped interview, ITSEC, November 2002, Orlando, FL: Integrity Arts & Technology, Inc.)

In this next segment, Dan Dwyer discusses the dangers of falling in love with technology

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It's very easy to fall easy to fall in love with technology. Technology is changing as rapidly as we've ever seen in the past, and the tendency to use technology for technology sake is not always the right decision. Sometimes just a simple off-the-shelf solution, a blackboard and a piece of chalk is as good as any new technology that we have to solve a problem. It really comes down to what is the problem that we are trying to solve, and what is the optimal solution for solving that problem.” (Dan Dwyer, videotaped interview, ITSEC, November 2002, Orlando, FL: Integrity Arts & Technology, Inc.)

These words of wisdom are important points to remember while attempting to manage the end-users' expectations and while considering the tradeoffs of adding capabilities or functionalities. Sometimes, end-users or developers may become so attracted to a technology that they request that capability without realizing that it will not help the project realize its purpose. To avoid this problem, remember to focus on the purpose at hand, rather than on the technology itself.

And lastly, Dan Dwyer has some words of wisdom reminding us that it is the human condition that should be our primary focus—not the technology (also see SMART, 2001).

Traditionally the human was just considered another variable that very often wasn't factored into some of the simulation decisions that were made. They were ultimately the end-user, but they weren't considered until after the fact. ... I've heard a phrase used, “The human become the shock absorber for poor design.” Very often when you have poor design, the human is expected to take up that slack and to absorb any of the deficiencies that might have occurred in the design of that equipment.

Over probably the last five, six, seven years the importance of the human in that equation has grown incredibly. ... Now, more and more the human is part of the design decision up front, taking into account his or her capabilities and limitations to better develop those type of training simulations and models that we use more and more in the military today. (Dan Dwyer, videotaped interview, ITSEC, November 2002, Orlando, FL: Integrity Arts & Technology, Inc.)

Topic Summary:

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In summary, as you work in the field of M&S, remember that in order to create effective models and simulations it is critical that we follow each step in the systemic development process. Additionally, avoid some of the common mistakes that people are making by following these practical guidelines:

- Continually validate throughout development
- Involve the end-user as a valued team-member
- Keep the model separable from the simulation
- Take sufficient time to develop a strong design before entering production
- Don't fall in love with technology. Instead, focus on solving the problem, manage the end-user's expectations and only add components or functionalities if they solve this problem and meet the ultimate need.
- Remember the human element while developing the model or simulation.

SUMMARY

In this topic, you will review the concepts presented in the M&S Process Module. The potential benefits of modeling and simulation can only be achieved if the community builds models and simulations that meet the needs of the end-user. While there is an established process to follow that can ensure the creation of effective end-products, all too often development teams--that are struggling under constricted timelines and budgets--skip critical design steps. While this may seem to help the project in the short run, it actually jeopardizes the success of the entire project and can cause serious loss of money, resources, time and end-user trust.

Here is a quick review of each of the development steps.

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During the Identification of the Need phase, the development team is formed, the end-user's needs are clearly articulated, and a common vision of a projected M&S solution is created. And most importantly, the team begins involving the end-user as a valuable team member, conducting continuous evaluation, and managing end-user expectations. These three practices begin in this early phase and continue throughout the life of the project.

During the Requirement Analysis phase, the development team and the end-user analyze the need in depth to identify the project's requirements. An analysis of alternatives may be conducted to help the team compare the risks, costs and benefits of each option and thereby identify which ones will be most feasible. By the end of the requirements phase, the team should emerge with the most promising concepts and solutions to be studied further in the next phase.

In the Research and Development Phase, the team identifies the best way to produce the simulation. This is done by testing the most promising alternative approaches selected in the previous phase, and ultimately determining which option will be the most successful. If the team is working effectively, the gap between the end-user's need and the project development should be narrowing.

During the production phase the focus shifts from developing the model to dynamically implementing that model into the simulation—and designs are thereby transformed into products. Typical activities include refining and finalizing the simulation design, implementing the model into the simulation, producing the computational system, hardware and software--as well as continuing user involvement through interface evaluation and training.

Essentials of Modeling and Simulation
M&S Process Module

During the Implementation phase, the simulation is delivered to the end-user and is applied to the original need. A summative evaluation should be conducted to measure how well the final M&S application meets the end-user's needs. The results of this evaluation can inform the development team on any areas that need revision-- and the development process would begin once again! Also, projects for the Department of Defense must comply with the formal end-process review called VV&A or Verification, Validation, and Accreditation.

And lastly, while working throughout these phases, development teams should practice the following guidelines:

- Continually validate throughout development
- Involve the end-user as a valued team-member
- Keep the model separable from the simulation
- Take sufficient time to develop a strong design before entering production.
- Don't fall in love with technology. Instead let the purpose drive the selection of the required functionalities, and
- Remember the human element while developing the model or simulation.